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THE CAMBRO-ORDOVICIAN LIMESTONES OF THE APPALACHIAN VALLEY IN SOUTHERN PENNSYLVANIA¹

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The limestones of the Appalachian Valley, which in the South are separated into many formations, have generally been treated as a unit in the North under the name Shenandoah, or other local terms, such as Valley, Lancaster, Kittatinny, and York. These rocks include all the strata between the Cambrian quartzites of Georgian age and the Martinsburg ("Hudson") shale of Ordovician age.

In a paper on the sedimentary rocks of South Mountain² the author briefly described the formations comprising the Shenandoah group in southern Pennsylvania. Later studies of these rocks in the Cumberland Valley of Pennsylvania have furnished data for a more complete description of the group, including the faunal content and correlation, based on determinations by E. O. Ulrich.

The formations comprising the Shenandoah group in southern Pennsylvania are as follows:

Shenandoah group	{	Martinsburg formation		{	Eden	}	Ordovician
				{	Utica		
				{	Upper Trenton		
				{	Lower Trenton		
		Chambersburg limestone 100-600 feet		{	Black River		
				{	Lowville		
				{	Upper Chazy		
		Stones River limestone 800-1000 feet		{	Lower and middle Chazy		
				{	Beekmantown		
		Beekmantown limestone 2250-2300 feet		{	Saratogan		
	Conococheague limestone 1635 ± feet					Cambrian	
	Elbrook formation 3000 ± feet		{	Acadian			
	Waynesboro formation 1250 ± feet		{				
	Tomstown limestone 1000 ± feet		{	Georgian			
	Antietam sandstone						

The general structure of the Cumberland Valley is a monocline, the oldest rocks of the Shenandoah group resting against the Cam-

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² *Jour. of Geol.*, Vol. XIV, 1906, pp. 201-20.

brian quartzites of South Mountain on the east, and the youngest rocks passing beneath the Ordovician shales and sandstones of North Mountain and its associated ridges on the west. The monocline is not simple, however, but is modified by numerous folds and faults that either repeat the strata or conceal them.

The following detailed descriptions relate chiefly to the portion of the Valley in the Mercersburg and Chambersburg 15-minute quadrangles, which lie just north of the Maryland state line, but brief references are made to the Carlisle quadrangle at the north end of South Mountain.

TOMSTOWN LIMESTONE

The Tomstown limestone is not well exposed because of its nearness to South Mountain, where the surface is thickly covered by wash. It is composed largely of limestone, both massive and thin bedded, in part cherty, with some shale interbedded near the base. On account of its relative solubility it forms a depression or valley between the mountain and the irregular line of low ridges and knobs of the Waynesboro formation. Its thickness, computed from the width of its outcrop and the dip of its beds, is about 1,000 feet.

The base of the formation is largely concealed but comprises some hydromica shale interbedded with the limestones resting on the uppermost beds of Antietam sandstone. The top of the formation is placed at the first sandstones of the Waynesboro formation.

In the eastern or Chambersburg quadrangle the Tomstown limestone forms a belt about one mile wide along the foot of South Mountain, spreading out to nearly double that width in places. At Little Antietam Creek it is offset by a diagonal fault and extends up the Antietam Valley into the mountains several miles.

But few fossils have been found in this formation. At Roadside, in the upper limestones of the formation, excellent specimens of *Salterella* sp. undet., with the characteristic invaginate structure, were obtained. Mr. Walcott also found in this limestone, at the foot of the mountain east of Little Antietam Creek, *Kutorginia* n. sp. and fragments of *Olenellus*. These definitely determine its age as Georgian (Lower Cambrian).

In central Virginia a formation 1,600 to 1,800 feet thick, occupying

about the same interval but apparently including beds which in the Chambersburg area are calcareous sandstones and are mapped with the overlying Waynesboro formation, has been named Sherwood limestone by H. D. Campbell. The new name Tomstown is from a village in the Chambersburg quadrangle. The formation has been recognized also in the Carlisle quadrangle to the north, where it forms a deeply weathered belt about the foot of the mountain, largely covered by wash.

WAYNESBORO FORMATION

The Waynesboro formation is a series of sandstones, purple shales, and limestones overlying the Tomstown formation. Because of its resistant siliceous character it forms hills and knobs, parallel to the mountain front. At the base are very siliceous gray limestones that weather to slabby porous sandstone, large round masses of rugose chert, and white vein quartz.

In the middle of the formation are dark-blue to white subcrystalline limestones and dolomites, which become siliceous upward and merge into mottled slabby sandstone and dark-purple siliceous shale at the top. The thickness of the formation, computed from the width of outcrop and dips, and allowing for minor folding, is 1,250 feet.

The formation occupies a belt about one-half mile wide along the east side of the Cumberland Valley in the Chambersburg quadrangle. Its most complete development is in the hills northeast of Waynesboro, from which its name is taken. It has been traced northward beyond Mt. Holly Springs in the Carlisle quadrangle, but is there seldom exposed.

The only fossils found in this formation are a few poorly preserved shells, two of which are identified as *Obolus* (*Lingulella*) sp. undet. They were obtained from sandy shale at the very top of the formation, just east of Waynesboro. They suggest Acadian (Middle Cambrian) age but are not conclusive.

In central Virginia the Buena Vista shale, described by H. D. Campbell, is at this general horizon, but, as previously stated, apparently has a different lower limit. It is described as bright variegated shale, 600 to 900 feet thick, with mottled limestone and shale in the lower part. Mr. Walcott found in it a species of *Ptychoparia* related to Acadian (Middle Cambrian) species of Tennessee.

ELBROOK FORMATION

The Elbrook formation is the thick series of gray to light-blue shaly limestone and calcareous shale that overlies the purple Waynesboro formation.

The formation is decidedly shaly, most of the included limestones being minutely laminated and weather readily into calcareous shaly plates. When unweathered the limestone appears massive and homogeneous and in places is quarried.

Near the middle of the formation are massive beds of dolomite and very siliceous or quartzitic limestone that weathers to porous slabby sandstone and frequently forms knobs and ridges. The formation is limited above by limestone conglomerates containing rounded vitreous quartz grains and others containing tabular fragments of limestone, which characterize the base of the overlying formation.

The thickness of the Elbrook, determined on the two limbs of the unsymmetrical syncline west of Quincy, is about 3,000 feet.

The Elbrook formation crosses the Chambersburg quadrangle in a belt about 2 miles wide, with numerous projections and re-entrants due to intricate folding. It has also been traced across the Carlisle quadrangle where the character of the limestones is the same, but shales increase in prominence.

The only fossils found in this formation were fragments of trilobites obtained from rather pure limestone near the base northeast of Waynesboro. The age of the rocks could not be determined from these fragments, but they suggest Acadian.

The limestone was once extensively quarried for ballast for the Western Maryland Railroad at Elbrook, in the Chambersburg quadrangle, from which the name of the formation is taken.

CONOCOCHIEAGUE LIMESTONE

The Conococheague limestone is characterized by beds containing thin sandy laminae and quartz grains that weather into hard shale fragments and thin slabby sandstones which generally give rise to rocky hills and rugged topography.

The base of the formation is usually easily determined because it is marked by siliceous beds and conglomerates that produce a ridge. The conglomerates are of two kinds; one is composed of rounded

limestone pebbles, 1 inch or more in size, in a matrix containing numerous round coarse grains of vitreous quartz; the other is composed of long slender fragments of limestone in a calcareous matrix, which, because the fragments are tilted at various angles, is called "edgewise" bed. Interbedded with the conglomerates are oolites and dark shaly limestones with red clay partings.

The body of the formation is a closely banded dark blue limestone, the bands varying from one-half inch in width to minute laminae. The banding is inconspicuous in the fresh rock but is brought out in weathering as yellowish sandy streaks across a light-blue or gray surface. Toward the top these partings become more numerous and sandy, and weather into hard sandy plates and sheets. Chert is not an important constituent of the formation in the Chambersburg and Mercersburg quadrangles.

The thickness of the formation is about 1,600 feet.

A section measured at Scotland is as follows:

90 feet.	Rather pure, light, shelly or platy limestone, probably Beekmantown-Granular crystalline limestone containing coarse "edgewise" conglomerate, oolite, and pink marble, with numerous slaty partings weathering to glistening shale particles.
300 feet.	Covered.
15 feet.	Fine-grained, pure, light limestone, "edgewise" conglomerate and cross-bedded limestone containing quartz grains
390 feet.	Covered. Lower portion contains impure dark limestone and large banded chert.
10 feet.	Banded, dark and light limestone.
270 feet.	Dark, rather pure limestone containing trilobites and oolite, with argillaceous partings weathering to soft shale or slaty partings.
40 feet.	Massive light-colored, dense, even-grained limestone, with few fluted siliceous partings.
70 feet.	Covered.
180 feet.	Corrugated impure siliceous banded limestone and hackly shaly limestone.
30 feet.	Dense, black, rather pure limestone.
40 feet.	Massive beds of crumpled, siliceous banded limestone.
200± feet.	Dense siliceous banded limestone with "edgewise" conglomerate, cryptozoan, and sandstone beds at the base.

1635 feet, total.

The Conococheague limestone occurs in a broad sinuous belt crossing the Chambersburg quadrangle from south to north. It is plicated into many folds northwest of Waynesboro, marked by ridges of rough topography, and just south of the Chambersburg pike its

basal member forms a high elbow ridge, which is faulted off on the west side.

A wedge-shaped inlier of Conococheague is brought to the surface by an anticline in the vicinity of Welsh Run, in the Mercersburg quadrangle, where the rocks are similar to those in the Chambersburg area, but the siliceous banding is less pronounced. In the Carlisle quadrangle neither the basal siliceous beds nor the sandy laminated beds at the top are prominently developed.

Few fossils have been found in this formation, and such as have been collected are poorly preserved and difficult of determination. At the base a few good specimens of trilobites and brachiopods were obtained in the western portion of Scotland, and fragments of the same were seen in the basal conglomerate. These comprise *Dikelocephalus hartii* Walcott; *D.* sp. undet.; and *Billingsella* like *B. desmopleura*. The trilobites place this part of the formation definitely in the Saratogan (Upper Cambrian). In the basal conglomeratic beds a species of *Cryptozoan*, probably *C. proliferum* Hall, characterized by a mammiferous surface, the elevations $\frac{1}{2}$ to 1 inch in diameter, is rather generally present. In cross section the fossil appears to consist of thin closely folded laminae, and is illustrated in the writer's former paper.¹

These siliceous banded limestones, together with overlying finely laminated purer rocks, were previously described by the writer under the name Knox limestone. The differentiation of the upper rocks as a separate formation, next to be described, necessitates the giving of a new name to these lower beds, and Conococheague, the name of the large stream on the banks of which, in the town of Scotland, the best exposures occur, has been selected. The Conococheague and the overlying Beekmantown, therefore, comprise the Knox group.

BEEKMANTOWN LIMESTONE

The Beekmantown is a rather pure limestone lying between the siliceous Conococheague below and the very pure Stones River above. A minutely laminated appearance on weathered surfaces of many of the beds, due to their impurities, and pink to white fine-grained limestone or marble are characteristic features of the formation. Near

¹ *Loc. cit.* p. 217.

the base are siliceous banded beds and large "edgewise" conglomerate, closely resembling the Conococheague formation. These have been separated as a transition phase under the name Stonehenge member of the Beekmantown.

The best exposure of the formation in the Chambersburg quadrangle is adjoining the Chambersburg-Gettysburg pike, where the following composite section has been measured by Mr. Ulrich and the writer.

Beekmantown Section, 1 Mile East of Chambersburg.

- Base of Stones River containing fine limestone conglomerate and laminar and oolitic chert.
- 600 feet. Interbedded fine-grained pure limestones and magnesian limestones, finely laminated in part and containing small quartz geodes. Porous sandy chert near top. Dark layers near base, mottled by magnesian material that weathers out, leaving pits and holes, contain numerous gasteropods and ostracoda.
- 375 feet. Alternating pure dove and gray limestones and magnesian limestones, with layer of sandy chert.
- 100 feet. Bluish to dove fine-grained fossiliferous limestone, at the base containing rounded quartz grains.
- 275 feet. Pink, fine grained marble, containing layers of milky quartz chert. Gasteropods of the genus *Ophileta*, *Maclurea*, and *Eccyliopterus* rather abundant.
- 285 feet. Pure dove and blue, fine-grained limestone, with some pink limestones. Contains fragments of *Trilobites*.
- 145 feet. Fine-grained dove to dark-gray limestone with fine conglomeratic and oolitic beds. Abundant chert in upper portion, in part oolitic and conglomeratic.
- 225 feet. Fine-grained light- to dark-gray limestone containing contorted laminae of sandy matter, that stand in relief or fall to sandy shale on weathering, and thick beds of "edgewise" conglomerate. Contain Gasteropods in upper portion and fine fragments of *Trilobites* in lower part.
- 260 feet. Dark- to light-gray limestone, with sandy laminae less developed than in overlying beds. Contain *Orthis*, *Ophileta*, and *Trilobite* fragments.
- Top of Conococheague, containing contorted sandy laminae and beds of coarse limestone conglomerate.

Stonehenge member

2,265 feet total.

In the Mercersburg quadrangle an excellent section of the Beek-

mantown occurs on Licking Creek near its mouth. Unfortunately the upper part of the formation is not exposed in the creek bank and is complicated by folding. The section measured by Mr. Ulrich and the writer is as follows:

Beekmantown Section, near Mouth of Licking Creek.

- Interbedded pure and magnesian limestones of Stones River type.
- 340 feet. Light gray finely laminated magnesian limestone and white dolomite, with cherts of rosette type at the top.
- 140 feet. Dark and light, coarse dolomite.
- Rocks here folded and largely covered; contains white domolite, dark-blue oolitic limestone, and dark coarse dolomite with yellow blocky sandstone fragments and rosette cherts. Exact continuity indeterminate, but the previous beds are apparently repeated by folding.
- 350 feet. Interbedded pure and magnesian limestones, with beds of coarse dark dolomite, and in the lower part beds of "edgewise" conglomerate; at base contains Gasteropods, Cephalopods, and Trilobites.
- 170 feet. Largely finely banded magnesian limestone with few pure limestones. Contains fine conglomerate beds and Gasteropods.
- 130 feet. Largely dolomite, some coarse and dark. Large scoriaceous black chert and coarse sandstone at the base.
- 290 feet. Chiefly dolomite, coarse and dark in upper part, with occasional pure fossiliferous limestone. Bed of granular limestone with numerous Ophileta and pinkish fine-grained limestone near middle, crossbedded banded limestone at base locally unconformable on underlying beds.
- 65 feet. Fine-grained limestone seamed with calcite and dolomite beds, with flinty chert containing Cryptozoan at the base.
- 130 feet. Partly covered. Lower part pure dark limestone with few beds of finely laminated magnesian limestone and fine white oolite near base. Small rough chert with casts of crystal at the base.
- 165 feet. Light-blue limestone with fine contorted sandy laminae that weather in relief. Contains fine dark conglomerate with red limestone pebbles and fragments of Trilobites.
- 530 feet. Purer fine even-grain limestone with few sandy partings.
- Sandy laminated limestone, much contorted, of the Conococheague formation.

2,310 feet, total.

The details of the sections in the two areas are quite unlike. Whereas beds of pure limestone and marble are common and chert infrequent in the Chambersburg section, the reverse is true in the Licking Creek section. The pure limestones have been extensively

quarried at Stoufferstown and Stonehenge east of Chambersburg. In the Mercersburg quadrangle, chert is sufficiently plentiful in the soil derived from the Beekmantown to produce low ridges. One horizon is just above the siliceous banded limestone of the Stonehenge member and in the Mercersburg area is included with the siliceous phase. The cherts are of various forms. Some are large, rough, scoriaceous masses, others are flinty in texture, banded, brecciated, granular, and oolitic; while the most unique forms are composed of super-imposed rosettes resembling heads of cauliflower. A Cryptozoan, apparently of the species described by Winchell as *C. minnesotensae*, occurs in these cherts.

An upper horizon of cherts, many of the small rosette form, occurs at the top of the Beekmantown in both areas, but is a ridge maker in the Mercersburg quadrangle.

The Beekmantown limestone is one of the most widely distributed formations in the area, occurring in a broad belt across the western half of the Chambersburg quadrangle, and in several anticlinal areas in the Mercersburg quadrangle. Its outcrops are generally deeply covered with soil with infrequent exposures, and furnish excellent farm land.

In the eastern belt it is closely folded in common with the enclosing limestones, and its outcrop is consequently very irregular in outline and width. In the Mercersburg quadrangle it forms large lens-shaped areas in the anticlinal uplifts of Welsh Run-Edenville, Mercersburg, Foltz, and McConnellsburg.

Although its fauna has been previously observed at various places in the Appalachian Valley, the Beekmantown has not heretofore been recognized as a distinct formation in this region, and little is known of its extent beyond the immediate vicinity of the area. It is known to maintain its lithologic and faunal characters as far northeast as Mechanicsburg, Pa. Although sparingly fossiliferous as a whole, a rather large variety of forms have been collected in this area.

The lower portion of the formation, including the Stonehenge member, is characterized by *Ophileta complanata* and of the 13 species collected the following have been identified by Mr. Ulrich:

Rhabdaria, cf. <i>R. fragilis</i> Billings.	Maclurea affinis.
Calathium sp. undet.	Eccyliopterus.
Orthis wemplei?	E. triangulus.
Ophileta complanata.	Bathyurus near <i>B. conicus</i> .

In the middle of the formation two faunas have been distinguished. The lower one, characterized by horn-like *Opercula*, small *Isochilina*, *Hormotoma artemesia*, and large thin-shelled *Maclurea*, occurs in both quadrangles and good collections were made at Licking Creek and near McConnellsburg. 15 species were collected of which the following have been tentatively determined:

Orthis cf. <i>electra</i> .	Eccyliopterus, cf. <i>triangulus</i> .
Maclurea affinis.	Isotelus canalis.
Horn-like opercula of an otherwise unknown gasteropod for which Mr. Ulrich suggests the generic name <i>Ceratopea</i> .	Bathyurus cf. <i>conicus</i> . <i>B. caudatus</i> . Amphion cf. <i>salteri</i> .
Liospira canadensis.	Leperditia cf. <i>Primitia gregaria</i> Whitfield.

The upper fauna of the middle division, characterized by *Syntrophia lateralis* and found only at Stoufferstown, is as follows:

Syntrophia <i>lateralis</i> .	Liospira cf. <i>laurentina</i> .
Maclurea ? <i>sordida</i> .	Orthoceras cf. <i>primigenium</i> .

In the upper part of the formation, which is characterized by high-spired turritelloid gasteropods and by *Ophileta disjuncta*, 17 species have been collected from the quarry at Stoufferstown, and the following tentatively identified by Mr. Ulrich:

Orthis (? <i>Dalmanella</i>) <i>electra</i> .	Hormotoma <i>gracilens</i> .
Maclurea cf. <i>M. oceana</i> .	Lophospira cf. <i>Murchisonia gregaria</i> Billings.
Ophileta ? <i>disjuncta</i> .	Cyrtocerina cf. <i>mercurius</i> .
Solenospira cf. <i>prisca</i> .	Trocholites <i>internestriatus</i> .
Turritoma <i>acrea</i> ?	

Mr. Ulrich, who determined all the fossils described under this and succeeding headings, correlates the foregoing lists with the Beekmantown of New York, and that name is therefore applied to the formation.

STONES RIVER LIMESTONE

Above the Beekmantown is a considerable thickness of very pure limestones with occasional magnesian layers. The greater portion of the limestone that is burned for lime in this area is obtained from

this formation. In general the formation is composed of three divisions:—a middle band of massive pure granular limestone containing the large gasteropod *Maclurea magna* and thin beds of black chert that weather into small rectangular blocks; an upper series of thin-bedded pure limestone; a lower series of interbedded massive pure beds and magnesian layers.

These divisions cannot be readily distinguished in all parts of the area, and at no place can the complete section be seen because the beds are several times repeated by folding and the outcrops are not continuously exposed.

The following is a composite section of the formation in the Chambersburg belt:

Thin-bedded, fine-grained, pure, dove limestone.	Feet 275+
Massive pure limestone containing <i>Maclurea magna</i> and black chert layers.	
Upper part, compact, blue to dark; lower part, light gray, granular and oolitic	150-200
Massive and thin-bedded limestone interbedded with magnesian layers	600+
	<hr/>
Total	1050+

In the western belts the cherty *Maclurea* horizon was not clearly observed and the three-fold division could not be made. At West Branch of Conococheague Creek, south of the Mercersburg-Greencastle pike, its thickness was determined at 800 to 1,000 feet.

In McConnellsburg Cove, west of Tuscarora Mountain, the exposures are exceptionally meager. At a quarry south of the Mercersburg pike the formation as exposed comprises about 575 feet of interbedded, pure and banded magnesian beds with very pure fine-grained dove limestone at the top.

The formation crosses the Mercersburg and Chambersburg quadrangles from north to south in five belts. The eastern belt lying in the Chambersburg quadrangle is intricately folded and faulted, and comprises several parallel strips.

In the next limestone belt to the west, the Welsh Run-Edenville anticline, the Stones River forms a narrow strip about $\frac{1}{4}$ mile in width on either side of the Beekmantown. In the Mercersburg belt it occurs as two narrow faulted strips. In the Foltz and McConnellsburg limestone belts, its outcrops are largely covered.

Few fossils have been found in this formation, except in the middle chert-bearing portion. These consist chiefly of gasteropods, ostracoda, cephalopods, and bryozoa. A few ostracoda (*Leperditia fabulites*) and *Tetradium* "*syringoporoides*" can usually be obtained from the fine even-grained beds in all parts of the formation; 22 species were obtained from the subgranular beds of the middle division, and the following have been tentatively identified by Mr. Ulrich:

Stromatocerium sp. nov.	Dinorthis cf. platys.
Tetradium " <i>syringoporoides</i> "—the single-tubed form of this genus so characteristic of the Stones River.	Strophomena aff. <i>S. charlottae</i> . <i>Bucania sulcatina</i> . <i>Maclurea magna</i> .
Glyptocystites sp. undet.	<i>Lophospira bicincta</i> .
Lingulella ? <i>belli</i> (Billings)	<i>Isorchilina</i> cf. <i>amiana</i> .
Hebertella borealis.	<i>Ampyx halli</i> .
<i>H. vulgaris</i>	

The massive shells and opercula of *Maclurea magna* are the most characteristic fossils of this division. From the standpoint of correlation the most noteworthy feature of the above list is that no less than eight of the species occur in the middle Chazy of the Champlain Valley.

Although only *Leperditia fabulites*, *L. cf. amiana*, and *Lingula manteli* were obtained from the lower beds of this formation in this area, 12 species were collected 30 miles down the valley at Martinsburg, W. Va., by Mr. Ulrich and the writer, of which the following have been determined:

Solenopora compacta var.	<i>Lophospira</i> cf. <i>perangulata</i> .
Cyrtodonta sp. nov.	<i>Helicotoma</i> ? sp. nov.
Matheria sp. nov.	<i>Oncoceras</i> ? sp. undet.
<i>Liospira</i> cf. <i>obtusa</i> .	<i>Leperditia fabulites</i> .

The fossils as well as the lithologic character of this formation are so nearly the same as those of the Stones River limestone of Tennessee that they are regarded by Mr. Ulrich as identical, and the name Stones River is therefore applied.

CHAMBERSBURG LIMESTONE

The Chambersburg limestone is the uppermost division of the Shenandoah limestone. It is characterized throughout the area by

fossiliferous thin-bedded limestones with argillaceous partings. It varies in thickness across the strike from a maximum of 600 feet in the Chambersburg belt to about 100 feet in the McConnellsbury Cove.

Its most typical development is in the Chambersburg belt throughout which fossils are abundant. The following section in the railroad cut $1\frac{1}{2}$ miles west of Kauffman is the most complete continuous section in this belt.

	Feet
Black shale (Martinsburg)	
Largely concealed, but probably chiefly shale (near the top are black carbonaceous limestone with conchoidal fracture, shaly dark crystalline limestone, thin sandstone, and 10 feet of coarse crystalline limestone containing <i>Lingulas</i>)	150
Calcareous shale and limestone	100
Nodular clayey limestone	50
Dark platy limestone	94
Compact dark limestone, very fossiliferous	108
Cobbly limestone containing numerous <i>Nidulites</i> , bryozoa, and a layer of cystid heads	105
Total	607

The "cobbly" character of the weathered outcrop of certain of the beds, due to a wavy lamination or clay parting that crosses the bedding at a high angle and, on weathering, gives rise to rounded lenticular masses resembling rough cobbles, is one of the noticeable features of this formation. The upper 200 feet of the formation is composed largely of shale with interbedded thin fossiliferous limestones.

In the Welsh Run-Edenville belt, $2\frac{1}{2}$ miles southeast of Mercersburg, the following section occurs on the banks of West Branch of Conococheague Creek.

	Feet
Fissile shale containing graptolites and lingulas	
Calcareous black shale and hard thin black carbonaceous limestones, 80 feet.	
Granocrystalline limestone, fossiliferous	2
Cobbly dark subcrystalline limestone, both massive and thin-bedded . . .	73
Coarse massive granocrystalline limestone with massive beds of pure fine-grained limestone	75

} Martinsburg shale.

Platy granocrystalline limestone, fossiliferous	25
Dark, subcrystalline limestone with wavy partings of shale, fossiliferous . .	150
Very thin-bedded pure fine-grained drab limestone followed by more massive pure beds with magnesian layers and fine laminations (Stones River)	
Total	325

The following section was measured $1\frac{1}{2}$ miles west of Markes on the west side of the Mercersburg belt:

	Feet
Fissile and calcareous shale (Martinsburg)	
Thick bed of coarse crystalline gray limestone, fossiliferous	5
Thin bedded and cobbly dark limestone with Nidulites and <i>Monotrypa</i> <i>hemisphericus</i> in upper part	45
More massive limestone, banded in part	45
Pure fine-grained dark limestone with large <i>Beatricea</i>	20
Dark compact limestone	20
Covered	60+
Thin-bedded pure fine even-grained drab limestone (Stones River)	150
Total	195+

In the McConnellsburg Cove, few outcrops of the Chambersburg limestone occur, and but one measured section was secured, 2 miles northeast of McConnellsburg, as follows:

	Feet
Fissile shale containing graptolites	
Hard black slate and thin slaty black limestone, (Martinsburg)	84
Covered	10
Gray marble and massive blue-veined limestone.	20
Dark shaly limestone with argillaceous partings, containing solenopora and bryozoa	68
Pure fine even-grained limestone (Stones River)	
Total	182

The Chambersburg formation forms a narrow band along the margin of the overlying Martinsburg shale throughout the Mercersburg and Chambersburg quadrangles except where it is cut out by faults. It is present also along this contact throughout the Carlisle quadrangle, but details of its character and thickness there are not known.

Nearly everywhere this formation yields on careful search an abundance and great variety of fossils, and those from the Chambersburg quadrangle differ from those obtained in the Mercersburg quad-

range. In the Chambersburg belt the formation may be divided into 4 faunal zones.

From the lower zone, characterized by *Dinorthis pectinella*, 20 species were collected, of which the following have been determined by Mr. Ulrich:

Receptaculites cf. occidentalis.	Hebertella bellarugosa.
Echinosphaerites sp. undet.	H. cf. borealis and vulgaris.
Orocystites?	Rafinesquina inquassa?
? Chaetetes cumulata.	Plectambonites pisum var.
Hemiphragma irrasum.	Triplesia n. sp.
Dalmanella testudinaria, small n. var.	Leperditia fabulites pinguis.
Dinorthis pectinella.	Ampyx normalis.

In the second division, characterized by *Nidulites*, 38 species were collected and the following tentatively identified:

Nidulites cf. favus.	Dalmanella n. sp. (aff. D. subaequata).
New genus of Amygdalocystidae.	Scenidium anthonense.
New genus of Pleurocystidae.	Strophomena cf. filitexta.
Bolboporites n. sp.	Rafinesquina cf. inquassa.
Praspora contigua.	R. cf. incrassata.
P. cf. lenticularis.	Leptaena n. sp.
Stromatotrypa (? Diplotryna) sp. undet.	Plectambonites cf. pisum.
Hemiphragma irrasum?	P. asper (Reudemann).
Stomatopora inflata.	Triplesia n. sp.
S. proutana.	Ampyx n. sp. (cf. A. normalis and A. halli).
Orthis sp. undet.	Pterygometopus cf. callicephalus (variety approaching P. schmidt).
Plectorthis n. sp.	Ceraurus pleuraxanthemus.
Dalmanella testudinaria var.	

In the third division, which is often crowded with fossils, 43 species were collected, of which the following have been determined:

Diplotrypa sp. undet.	Arthropora cf. bifurcata.
Rhinidictya cf. neglecta.	Rhinidictya cf. neglecta.
Plectambonites n. sp.	cf. Trematopora ? primigenia.
Leptaena n. sp.	Orbiculoidea cf. lamellosa.
Parastrophia cf. hemiplicata.	Orthis cf. tricenaria.
Ulrichospira n. sp.	Scenidium cf. (Merope).
Echinosphaerites sp.	Dinorthis n. sp. (aff. D. subquadrata).
Hemiphragma cf. irrasum and otawaensis.	Strophomena n. sp.

<i>Strophomena</i> (? <i>Leptaena</i>) cf. <i>charlottae</i> .	<i>T.</i> cf. <i>nucleus</i> .
<i>Plectambonites asper</i> .	<i>Protozyga exigua</i> .
<i>P.</i> <i>pisum</i> .	<i>Orthoceras</i> cf. <i>juncum</i> .
<i>P.</i> n. sp. (near <i>P. pisum</i>).	<i>O.</i> cf. <i>arcuoliratum</i> .
<i>P.</i> n. sp.	<i>Lepidocoleus</i> 2 undet. species (near <i>L. jamesi</i>).
<i>Christiania trentonensis</i> .	<i>Isotelus</i> cf. <i>gigas</i> .
<i>C.</i> n. sp.	<i>Iliaenus consimilis</i> .
<i>Triplesia</i> n. sp.	Fragments of <i>Trinucleus</i> or <i>Tretaspis</i> .

In the upper, or Sinuites, zone, which is immediately beneath graptolite-bearing shales, 31 species were collected, and the following determined:

<i>Diplograptus</i> sp. undet.	<i>Turrilepas</i> sp. undet.
<i>Lingula riciniformis</i> ?	<i>Ctenobolbina</i> sp. undet.
<i>Lingulops</i> sp. nov. ?	<i>Ampyx</i> n. sp.
<i>Conotreta rusti</i> .	<i>Trinucleus concentricus</i> ?
<i>Rafinesquina</i> cf. <i>ulrichi</i> .	<i>Harpina ottawaensis</i> ?
<i>Sinuites cancellatus</i> .	<i>Triarthrus becki</i> .
<i>Cyclora minuta</i> .	<i>T.</i> <i>fischeri</i> .
<i>C.</i> <i>parvula</i> .	<i>Calymene senaria</i> ?
<i>Microceras</i> cf. <i>inornatum</i> .	<i>Bumastus</i> sp. ?
<i>Coleolus</i> cf.	<i>Bronteopsis</i> ? sp. undet.
<i>Trocholites</i> sp. undet.	<i>Proetus latimarginatus</i> .
<i>Caryocaris</i> sp. undet.	<i>Cyphapis matutina</i> .

In the Mercersburg quadrangle 4 faunal zones are also distinguished but they do not correspond with those of the Chambersburg belt. The lower zone comprises 20 species, largely new and undescribed, of which the following are tentatively listed:

<i>Licrophycus</i> cf. <i>ottawaensis</i> .	<i>Dalmanella</i> cf. <i>testudinaria</i> .
<i>Lockeia</i> sp. undet.	<i>D.</i> <i>subaequata</i> .
<i>Cliocrinus</i> n. sp. ?	<i>Rafinesquina minnesotensis</i> .
<i>Raphanocrinus</i> ? n. sp.	<i>Strophomena</i> cf. <i>flitexta</i> .
<i>Echinosphaerites</i> sp. ? plates only.	<i>Plectambonites asper</i> .
<i>Helopora spiniformis</i> ?	<i>Gonioceras chazyense</i> .
<i>Rhinidictya neglecta</i> .	<i>Thaleops ovatus</i> .
<i>Escharopora ramosa</i> .	<i>Pterygometopus</i> cf. <i>schmidti</i> .

Of the 48 species collected in the second zone, the brachiopods and bryozoa that have been identified by Mr. Ulrich are regarded by him as suggesting the upper Chazy of New York:—

Solenopora compacta.
 Camarocladia cf. rugosum.
 Columnaria halli.
 Tetradium columnare.
 T. cellulosum.
 Caryocystites sp. nov.
 Anolotichia impolita.
 Nicholsonella laminata.
 Batostoma cf. magnopora.
 Hemiphragma irrasum.
 Helopora divaricata ?
 Rhinidictya fidelis.
 Pachydictya cf. foliata and robusta.
 Escharopora confluens.

Phylloporina reticulata.
 Hebertella borealis.
 H. vulgaris.
 H. bellarugosa ?
 Rafinesquina sp. undet.
 Strophomena (? Leptaena) charlottae.
 Plectambonites asper.
 Rhynchonella plena.
 Zygospira recurvirostris.
 Leperditia cf. fabulites.
 Isochilina cf. gracilis.
 Platymetopus cf. trentonensis.

The third zone, characterized by Beatricea, is regarded as representing the Lowville ("Birdseye") of New York. Of the 37 species, the following have been identified.

Beatricea n. sp.
 Tetradium cellulosum.
 Echinospaerites sp.
 Mesotrypa ? sp. undet.
 Diplotrypa ? sp. undet.
 Stictoporella sp. undet.
 Dinorthis cf. meedsi.
 Triplesia sp. nov.
 Zygospira uphami.

Helicotoma planulatoides.
 H. verticalis ?
 Omospira cf. alexandra.
 Leperditia cf. fabulites.
 Isochilina n. sp. (cf. I. gracilis).
 I. n. sp. (cf. I. ottawa).
 Macronotella ulrichi.
 Drepanella macra.

The upper division is the Sinuites zone, and although it corresponds with the upper zone of the Chambersburg belt, it is not succeeded directly by the graptolite-bearing shale but by a considerable thickness of intervening barren calcareous shales and thin black limestones. Of the 32 species the following have been identified by Mr. Ulrich, who correlates them with the Normanskill division of the Trenton of New York.

Hindia sp. undet.
 Lingula riciniformis.
 Lingulops n. sp.
 Dalmanella n. sp.
 Dinorthis cf. germana and subquad-rata.
 Plectambonites pisum.
 P. n. sp. (1) (aff. P. transversalis).
 P. n. sp. (1) (aff. P. sericea).

Christiania n. sp.
 Triplesia n. sp.
 Sinuites cancellatus.
 Cyrtolitina nitidula.
 Eccyliomphalus spiralis.
 Strophostylus textilis.
 Cyclora minuta.
 C. depressa ?
 Orthoceras junceum.
 Trinucleus concentricus ?
 Cyphaspis matutina.